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357

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"There cannot be a greater mistake than that of looking superciliously upon practical applications of science. The life and soul of science is its practical application" - Lord Kelvin 1883.

THE ORGANISATION OF METEOROLOGICAL ADVICE FOR AGRICULTURE AND INDUSTRY.

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0107250

1 THE MANAGEMENT OF RESOURCES

"Science" we take to be an activity aimed at moving back the boundaries of human knowledge. This interrogation of nature is supported not because there is necessarily a specific practical end point in view, but because it is considered desirable in itself.

"Technology" we take to be research and developmental efforts aimed at specific practical goals. It is supported to the extent that its objectives are thought to be important by its sponsoring body.

I think we have to keep the distinction between science and technology clear in our minds. Certainly the objectives are different, the end products are different, and the people and organisations involved need to be managed in different ways.

The consensus of opinion in recent years would appear to be that whilst British science has continued to demonstrate its strength, British technology has proved far from adequate. Whilst one must recognise that scientists and technologists (in the sense of our initial definitions) are not necessarily interchangeable, nevertheless those capable of making significant progress when they reach the boundaries of present knowledge, are likely to be the exception rather than the rule. It could therefore be argued, that the weakness of technology when compared with science, should be placed squarely on the shoulders of those who have partitioned our scientific and technological efforts in the recent past. To reiterate, technology will only be supported to the extent to which its specific goals are seen to be important to its sponsors.

The problem of the management of scientific resources is not peculiar to the United Kingdom. (Lithwick, 1970) in his analysis suggests for example "that Canada too has failed to harness science to economic growth or to solving social problems; and because there is no science policy coupled with national growth, areas of economic activity crying out for technological break through will remain in the back water. Decisions about the allocation of resources are in the hands of scientists and until there is a coherent science policy, stress will be placed on the new frontiers of science, because the alternatives lie outside the ken of this clite".

In this last phrase it seems to me at least, that we have identified one major restriction to the advance of technology.

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The scientist traditionally found at universities and similar centres of learning, is not automatically or even necessarily familiar with problems outside his own specialisation, but yet represent the obvious source of independent advice open to Government, its committees and its institutions. If such advisers now continue to see their end results as new concepts expressed in learned papers, and if the allocation of resources is guided primarily by those who see speculative research as the only worthwhile study, then there is no a priori reason to suppose that operational research will function effectively at the same time.

There is competition for limited resources (men and money). The problems proposed for study arrive through quite different channels of communication in the two cases (down from the top, as opposed to upwards from the grass root level) and if priority is allocated to those identified by conceptual rather than real life situations, then we have already lost the only immediate point of contact with the potential, practical user of the study.

Another and quite substantial difficulty here is that real problems seldom come in 'discipline shaped blocs' and the multidisciplinary approach required for their solution has been known to be pronounced an anathema.

It is obvious that the organisation of technology requires 'T-shaped individuals' in the management sense, if we are to break down the barriers between the isolates of government, industry, university and the financial community. The problems may have changed since the time of Lord Kelvin, but the situation which prompted his remarks is apparently still with us.

To emphasise inadequate communication as a restriction to the harnessing of science, we do not even need to stay with the natural sciences for further illustration. The social scientists of this country have been scandalised to find that the simple publication of an academic analysis is no guarantee that its findings and implications will be acted on in the day to day world. The Social Science Research Council Report (1969/70) tells us that "It may be that the analogy drawn between the natural and the social sciences has led to the practioners of the latter to under-estimate the extent to which effective research requires a much more active participation in the process of the diffusion of the results". Evidently the social scientists are discovering the hard way that even if the problems tackled are those to which others would like to have answers, then even when a satisfactory model of the situation has been set up, validated and simulated, there is no progress in the real world until results have been communicated back to it, in terms that it can understand.

The key to the successful harnessing of science, and the management of scientific resources to thus end, would appear to be involvement-involvement in the problems of others in order to identify objectives - involvement in the efforts needed to translate ideas, analyses and understanding into effective action and change.

2 OBJECTIVES IN METEOROLOGY

Why and how as meteorologists do we have an interest in agriculture and industry?

The problems implicit here can be considered under 3 general headings.

The first concerns the interrogation of nature, the exploration of those aspects of climate, weather and environmental physics that are relevant.

The second concerns objectives in meteorology.

The third concerns the evaluation of environmental data and understanding - the translation of meteorological events into events of significance in other fields; a quantitative study of the interactions between the environment and various facets of production, storage and distribution should lead on to rational and routine procedures to put this knowledge into action.

Now the sequence in which these headings are placed is quite deliberate.

The first presumably is not controversial; we have to start from the basis of facts.

But unless our objectives comprehend the third type of problem, we do not even begin to become involved in the efforts needed to translate ideas, analyses and understanding into effective action.

The answer to the question "Why an interest in agriculture and industry?" is simply that we place the user and potential user of meteorological advice at the centre of our deliberations; real problems are seldom strictly meteorological but we follow where they lead us.

In meteorology, both science and technology are presumably open to us. These activities are not mutually exclusive, but if we recognise a distinction between them, then we have to decide where our greatest effort should be placed.

Among the general statement of aims of any meteorological organisation, I personally should like to see the following included:

To write business objectives into meteorology.
To develop meteorology as a management aid.

Science has to be supported by society; it is not unreasonable for society to ask in turn that whatever dividends there are of a practical nature should be extracted and exploited. Only the acceptance of some such objectives as the above will provide the working environment that enables this to be done.

3 METEOROLOGY AS A BUSINESS

If a business is a system for converting a resource, namely knowledge, into a contribution of economic value, then this is surely true of, say, weather forecasting. But a weather forecast has no utility of itself. And so we are brought face to face with the simple business truth which states that in any organisation there are no results, only costs; results depend on people outside the organisation. For those who do not accept that meteorology is for the meteorologist, but for the benefit of the community at large, it is very apparent that the economic value of meteorological advice is nil until somebody, somewhere, takes decisions based upon it; that for those outside meteorology, weather information is not an end product, but simply a starting point. Our output is simply a management input in other fields, and we need to develop meteorology as a management aid in order to make our output effective.

To write business objectives into meteorology is an immediate declaration of an interest in economic results.

Our business has two basic objectives:

i. Marketing
ii. Innovation

What is there to market in a monopoly public service? The purpose of a busines is to create a customer and marketing is the matching of the service given by any organisation with the customers requirements, within the financial constraints laid down. This applies whether we are marketing food or textiles or I suggest, meteorological advice.

Innovation is the provision of more economic goods and services. It embraces improvement in the product, in marketing techniques, in management and organisation methods.

It commits us to technological advance, rather than to problem solving as this is generally understood.

It allocates small priority to problems seen as difficult questions requiring tactical decisions for the restoration of normality.

It allocates great priority to problems seen as situations which require that the right questions should be asked. It is concerned with finding out what the situation is and what needs to be changed; and it achieves this by setting the right objectives.

Innovation is concerned with improvements in efficiency in any field. It could for example be argued that management techniques, developed for use in business, should have an obvious (in logic) value, in the management of any large organisation. That they were developed first for business rather than to meet the problems of other organisations is not to call in question their more general applicability, but simply a manifestation of the urge for profit; there is money in efficiency. There should be some benefit, perhaps

not always measurable in money terms, from running a city well or a health service or even a meteorological service. Profit can be replaced by value for money.

How far would these business objectives go to meet the disparity between knowledge and its effective realisation, which is the burden of the analyses made by the writers quoted?

There is no doubt that they would go some way to reverse the priorities that have been given to "science" and "technology" in the past. To opt for such a change would not be to write off any interest in academic studies. The supposition here is that those capable of science (in our terms) can and would select themselves when brought up against technological problems. Implicit in innovation is the quality to see things in the round, to synthesize, to generalise, to question - to question accepted practice and to question fundamentals. Implicit in marketing is that the technological problems tackled should be selected by reference to industry and society. The aim is not only to provide the answers that industry and society needs now, but also the answers it will require in 5, 10 or 20 years' time. Implicit in marketing is that products and services should be seen through to a satisfactory working conclusion..

4 AGRICULTURAL METEOROLOGY

In the organisation of meteorological advice for agriculture, there is the immediate and obvious distinction between the information obtained in the conventional, routine general weather forecasts and the work carried out by the agricultural meteorologist, who is concerned with the evaluation of meteorological and environmental data of all kinds.

4 1 WEATHER FORECASTS

a

As applied meteorologists, we are committed to practical ends and to the provision of an effective service. My concern here is not so much with the immediate weather of the next 12-24 hours, but with the longer term weather prospects as an aid to the forward planning of field work. Now the need for quantitative statements does not diminish as the period of the forecast is extended; meaningful parameters such as rain days or rainfall amounts are needed, rather than some indication of the future location of features on a synoptic weather map. One has to realise also that given meaningful meteorological parameters, the relationships between these and the possibility or advisability of field work may at present only be known to the agricultural meteorologist or to the agricultural advisory service.

Seasonal forecasts are not yet with us, monthly forecasts are made but the statements they contain are fairly general. Weather is indicated by the departures from the climatological average of monthly mean rainfall and air temperature, but some attempt is also made to indicate the timing and sequence of changes of weather type

that will inevitably occur over a period of the order of 30 days. The conventional monthly weather forecasts may represent the best guidance that can be offered. However, unless they can be made more quantitative than they are at present, then it is unlikely that we can begin to be specific about weather dependent activities such as field work. This suggests that we have to content ourselves with the implications to be drawn from the weather forecasts for a few days ahead, at most a week.

If our aim is taken as the interpretation of the longer term weather prospects for the forward planning of field work, then the weather forecast for the coming week that is presented in the farming programmes broadcast each Sunday, would appear to offer the most realistic scope for development.

In addition we know that the past weather has a bearing on field operations both in the short and long term. The rainfall of last week may still dictate trafficability this week. The time to harvest will be determined in no small measure by the weather of the season so far. Weekly intervals would appear to be suitable and convenient periods for presenting summaries of past weather and to comment on the occurrence of critical or threshold values of meteorological parameters of some biological import on the farm.

The following tentative schedule is put forward as a feasible undertaking to be included in a once weekly broadcast aimed specifically at farmers (a breakdown of the headings and possible topics for comment is shown in an appendix).

1 THE WEATHER SUMMARIES

a The past week.

b The season so far.

c Comment on the success of the forecast and agricultural inferences over the past week.

2 THE WEATHER FORECASTS

a The conventional weather forecast for the coming week.

b The conventional weather forecast for the coming month.

3 THE AGRICULTURAL IMPLICATIONS OF THE FORECAST

a For the coming week.

b For the current season

This project may appear over ambitious but as applied meteorologists we have to follow where our problems lead us. It is only fair to point out that this schedule and the details of the appendix were developed in conjunction with the Agricultural Development and Advisory Service (ADAS).

For this service to develop satisfactorily I would suggest that it has to be approached on a regional basis. This in itself presents an initial problem in that whilst the BBC regions may divide the country from north to south, a more natural division of farming interest might be from east to west. The requirements of the arable farmer are not necessarily those of the grassland or hill farmer or even of the horticulturalist. In the early stages it would perhaps be essential to concentrate on an area of reasonably coherent farming activities so that user interests should not be dispersed by general statements (such as will inevitably occur if one attempt to cover the range of farming throughout the British Isles in a single broadcast).

Reality has to be brought into the programme. A reference to the success of the forecast of the previous week helps. A reference to the work actually carried out by an Experimental Husbandry Farm (EHF) might carry more weight. A reference to the projected work of an EHF over the coming week might serve as a useful reminder to the projects farmers should be currently prepared to tackle.

Still on the subject of reality, a trial period (perhaps over a complete farming year) would be needed before one could consider presenting the information to the general public. Such a trial, and access to the EHF records, would obviously involve the ADAS of the region and entail the acceptance by the stations and the individuals nominated to liaise with the meteorologists of the aims and worthwhileness of the exercise. Such a trial period together with comment from the ADAS would also serve to indicate where the present weather/field work relationship are found wanting.

4 1 MARKETING METEOROLOGY
b

The concept of the business approach is certainly not new to the agricultural meteorologist even if it has not been explicity stated before; we have only to witness the early association in this country with the agricultural extension service.

Business objectives argue that at the very least for the maintenance, if not for the positive reinforcement of this present co-operation with ADAS.

A business approach emphasizes innovation rather than problem solving; but if we are to remain in close contact with the agricultural extension service, an organisation partly concerned with "trouble shooting", then it is inevitable that many practical problems presented to ADAS will extend a requirement for meteorological data and for an evaluation of the environmental physics of the problems. Seen in this light, problem solving is simply part and parcel of the marketing of meteorology. If, however, we are not to be managed by our "in-tray" and the problems that are presented from day to day, not only must we have an overall set of objectives, but also a sensible staff structure to enable both the short term (more mundane, but certainly economic) problems of the individual grower to be tackled, and also the longer term, strategic problems, which may have some repercussion on the industry as a whole.

I would suggest that marketing, in the sense of problem solving, largely handles itself, provided that there are easy channels for physical communication between members of the extension and meteorological services and, (and this is important) the people concerned are of the same calibre.

Market research follows as a simple corollary.

4 1 c THE MANAGEMENT OF INNOVATION

The continuing and central problem of management for agricultural meteorology is that of the management of innovation.

In agricultural meteorology we are concerned with turning ideas into commercial reality (a management aid). We have the advantage over manufacturing industry that we do not generally have to produce hardware, and basically we are concerned only with ideas, their validation and their marketing. (Our technical competence in research and development is assured if the staff is right).

Now it is possible to find in the literature, recommendations on the environment and organisation which are favourable to the generation of innovation (Casimir and Gradstein, 1966). One can find check lists for creative thinking (Eiloart, 1969). One may examine case histories of particular innovations in industry (Cahn, 1970) and follow through the economic, political and managerial arguments as to why particular projects (and countries) fail to do as well as others.

One may do all these things and yet if one relies on serendipity, then innovation may still fail.

One way of improving this situation it seems to me is to institutionalise innovation, by deliberately making it part of the management function.

Having set down the overall objectives, management has to formulate a summary of the strategies which will be followed to realise the objectives. These lead on to the tactical action required in the field of research and development, and marketing. At the tactical level we can now identify and emphasize the invention and innovation required to ensure the success of the strategies.

Some method of sorting or ranking a variety of possible programmes is necessary in order to find which ones fit best with the available (manpower) resources.

Innovation follows on from "science", but does not have to wait upon "new science". I suggest one useful strategy would be the systematic exploration of our present state of knowledge for innovation ideas, bearing in mind current trends, likely developments and the present subjects of research both in meteorology and agriculture, and also the type of problems that reach us.

It is probably too much to expect that developments in one field will parallel the requirements in the other, but we could use such an analysis to identify changes in the one that called for a complementary development in the other.

Take a few examples for meteorology. We have the advent of computers, the possibility of extended quantitative forecasts, the appearance of new observational techniques.

Computers suggest that we should examine our procedures for data storage (and retrieval) and computation.

Is our hand processing of data still necessary?

Has there been collaboration with the GPO on automatic "reading" of script and figures?

If our literature retrieval is to be based on a "keyword" system, then does WMO have a project to produce an internationally agreed set of words?

In some of our work we are concerned with the matching of meteorological and farm/biological data and a search for coincidences. How could this most conveniently be done by machine instead of as at present by hand?

People are constructing "models" for plants and disease growth, writing in day to day weather as a factor. What are the implications for our climate and agricultural industry?

With computers available to do the calculation, what have we to offer to those interested in buildings and the weatherproofing of farm enterprises and farm products in general?

It may be a reasonable inference that the average farmer is capable of interpreting the conventional weather forecast for the next 12-24 hours in the light of his intended field work, the state of his crops and the state of his ground. It may be no more than an act of faith that the average farmer can make use of conventional extended weather forecasts. Are we developing the necessary relationships between the meteorological parameters used (or likely to be used) in extended forecasts and parameters significant on the farm, ie machinery work days?

New observational techniques are becoming available to monitor the atmosphere and its under-surface on a synoptic scale. How could we use satellite techniques, telementry, and new sensors (for example, infra-red hand sensors) in our work?

In agriculture we take simply one example, the work of the plant breeder. Selection is made on the basis of a few years' trial. Are we sure that the correct weather factors are being written into the data being compared? Were the years of the field trials of a particular variety extreme and unrepresentative of a longer period sample of years?

There are cereal varieties which do reasonably well in most seasons; there are other varieties which will do much better than "reasonably well" given the right season. Can we influence the breeders and the farmers' choice?

5 CONCLUSION

This symposium is primarily concerned with weather forecasting for agriculture and industry, but it is perhaps as well, at an early stage in the proceedings, to dispose of the misconception that weather forecasting is the whole of meteorology.

The applied meteorologist is not concerned with the production of weather forecasts as such. His role is played before and after; before - in identifying the weather sensitive problems that the grower and businessman need answered; after - in communicating the implications of weather and environmental data to these people.

To do this he needs to understand the interaction between weather (or climate or environment) and particular facets of industry. He needs validated working models of weather sensitive situations in which 'weather' inputs lead to outputs directly applicable to managerial decisions in other fields. Weather forecasting now is not simply an exercise whose success is to be measured by the progress of lines across synoptic weather maps, but rather one whose success is to be measured by the economic results of decisions taken under conditions of risk and uncertainty.

To market meteorology successfully to business enterprises, the meteorologist needs to become involved, to the extent that business objectives are applied, quite naturally, to meteorology itself.

I have tried to set down some of the attitudes and implications inherent in such an approach. In the light of my earlier quotations you might like to consider whether these implications should find more general acceptance in 'science-based organisations' as a whole. But it is only fair to say, that if these attitudes in themselves would represent an innovation for the organisation considered as an entity, rather than as the sum of its parts, then (Haggerty, 1970) would not be very sanguine about their implementation.

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APPENDIX

THE WEATHER SUMMARIES

(a) The Past Week

1. Rainfall amounts
   Raindays
   Snowfall

2. Soil temperatures
   Depth of frozen soil
   Occurrence of freezing and thaw in the ground

3. Air temperatures
   Number and Severity of air and ground frosts

4. Sunshine hours
   Potential transpiration/Soil Moisture deficits

5. The occurrence of weather suitable for the spread of disease or infection e.g. Smith periods, Beaumont periods, Cereal Mildew infection days.

(b) The Season So Far

1. Rainfall - compare with normal expectation
   - comment on soil moisture deficits (irrigation need)
   - comment on excess of rain over field capacity (leaching)

2. Soil temperatures - compare with normal expectation
   - compare with normal expectation of first and last date of soil temperatures reaching 42°F.

3. Air temperatures - comment on normal expectation
   - compare with average date of first and last frosts; average duration of frosts
   - comment on accumulated temperatures (normal; time to harvest)

4. Sunshine hours - compare with normal expectation (time to harvest)
   - potential transpiration
   - effective transpiration (time to harvest)

5. The indications for the occurrence and severity of

   (i) animal diseases
   (ii) insect pests and vectors
   (iii) plant diseases

6. Effect of season's weather on crop, in so far as this may be relevant to storage treatment i.e. time in store of top fruit.

(c) The Success of the forecast for the previous week

Rain days/work days at EHF (type of work)
Air or ground temperatures/work days of EHF
Changes of weather type

THE WEATHER FORECASTS

(a) for the coming week

A conventional presentation with synoptic maps.

Emphasis on changes of weather type
on sequence of rain days
on the normal meteorological hazards to farming
e.g. snowfall (exposure of stock trafficability)
strong winds (exposure, physical damage, heating costs)
extended dry spells
extended wet spells
mild humid spells

(b) for the coming month

A conventional presentation

THE AGRICULTURAL IMPLICATIONS OF THE FORECASTS

(a) the coming week

Given - Rainfall amounts
- Number of rain days
- Sequence of wet and dry days

We suggest - the total number of days likely to be available for field work.

- the likelihood of being able to begin autumn ploughing.

- whether heavy land should be worked down immediately after ploughing or not.

- whether spring ploughing, spring cultivations are going to be possible (in conjunction with soil temperature).

- whether the sequence of dry/wet days will favour germination or the rooting of transplants (in conjunction with soil temperature, soil moisture deficit and possible wind blow).

- whether a spray programme will be possible or advantageous (in conjunction with soil moisture, sunshine, soil temperature).

- whether it will be possible to harvest or carry field crops (in conjunction with soil moisture, sunshine, soil temperature).

- whether the carrying or application of fertiliser will be possible or worthwhile (in conjunction with soil moisture, soil temperature).

- irrigation need in general terms.

Given Air temperatures) absolutely or in terms of
Soil temperatures) change from previous week
Likelihood of air frosts

We suggest - sowing dates
- beginning and end of growing season
- probable demand for frost protection devices for field crops
- probable demand for heating of glasshouse crops (in conjunction with wind)
- degree of exposure to stock kept outside (in conjunction with wind, rain)
- possibility of conditioning grain or potabo bulks

(b) The current season

Leaching - amounts of fertiliser to be applied
Time to harvest
Type of harvest - hay or silage - Single or several fruit pickings
Amounts and quality of harvest - level of stock feed and supplements for the coming winter

Possible or permitted run down of stockfeed
Irrigation need - whether in general terms irrigation be continued to avoid secondary growth.
Time of return to field capacity - autumn work days.